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ABSTRACT

This study determined whether or not there were certain aspects of cognitive/personality style which affected prospective teachers' choice of rule-example order in teaching mathematics. Seventy undergradvate elementary education majors were given the Paragraph Completion Test which measures conceptual level and the Group Embedded Figures Test which measures field-dependence-independence, along with a self-report instrument designed to measure choice of rule-example order. Results suggest that prospective teachers' choice of mathematics rule-example order is differentially affected by their conceptual level and field-dependence-independence. (A bibliography and tables are included.) (Author/RC)

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Choice of Rule-Example Order used to Teach Mathematics as a Function of Conceptual Level and Field-Dependence-Independence

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ABSTRACT

This study was designed to determine if there were certain aspects of cognitive/personality style which affected prospective teachers' choice of rule-example order in teaching mathematics. 70 undergraduate elementary education majors were given the Paragraph Completion Test which measures conceptual level and the Group Embedded Figures Test which measures field-dependence-independence, along with a self-report instrument designed to measure choice of rule-example order. Results suggest that prospective teachers' choice of mathematics rule-example order is differentially affected by their conceptual level and field-dependence-independence.

In the search for the characteristics of the effective teacher, teaching experience has not proven valuable (Fey, 1970). For we do not know what experience teaches the individual teacher, nor do we know, among many other aspects, what the individual teacher brings to the classroom in terms of cognitive/personality style and its effect on classroom presentation. Prior to entering the classroom the prospective teacher has spent years in the classroom as a student and from this complex experience and the individual's personality an initial teaching style is constructed. This study was designed to determine if differential aspects of cognitive/personality style held by prospective teachers related differentially to presentations in teaching. More specifically, the present study was to investigate the relationship of prospective elementary school teachers' conceptual level and field-dependence-independence with their choice of rule-example order in teaching mathematics.

Fey (1969), reporting the findings of the Minnesota National Laboratory Study of the School Mathematics Study Group program, states that "the most significant predictor of teaching effectiveness was the productive thinking ability of teachers . . . . the most effective teachers produced more . . . alternative ways of teaching course concepts (p. 55)." In Hunt's (1971) terminology, these teachers functioned at a higher conceptual level than those teachers who were less effective. While Hunt describes learning style in terms of conceptual level, and defines it "in terms of how much structure a student needs to learn best (1972, p. 24, Hunt's italics)," a complementary description of teaching style may be defined

in terms of how much structure a teacher requires in presenting concepts in the classroom in order to feel effective. In Hunt's model, a student who has a low conceptual level; i.e., not capable of generating his/her own concepts, will learn best when the environment is highly structured. In this approach, the material is best presented in an organized, direct manner which avoids ambiguous situations. On the other hand, a student who has a high conceptual level is self-reliant, capable of considering many alternatives and functioning in a variety of environments. A parallel construct would suggest that a low conceptual level (CL) teacher's presentation would be high in structure so as to eliminate ambiguity, whereas a high CL teacher's presentation would provide for more student-teacher interaction. In considering the choice of rule-example order by prospective teachers, this construct (after Tomlinson and Hunt, 1971) would map a high structure approach onto a presentation where the rule is presented first, followed by examples; a medium structure approach where, while mathematics examples are presented first, they are few and followed immediately by the mathematics rule; and a low structure approach where many examples are presented first and the mathematics rule at a later time. In order to anticipate who the teacher would prefer to state the rule--the teacher or the student--the cognitive style of the field-dependent-independent teacher needs to be considered.

The work of Witkin and others (Witkin et al., 1962; Goodenough & Karp, 1961) has demonstrated that field-dependence-independence, which was originally used to measure perceptual organization, reflects other aspects of personality style. It has been found that field-dependent people are more socially oriented than field-independent people (Justice, 1969; Holley, 1972).

Field-independent people, who are much better at disembedding a figure from within a field, are also in general more attracted to occupations where social interaction is limited and analytical skills are required (Witkin and Moore, 1974). As such, relatively field-dependent teachers are more likely to choose a socially interactive classroom than field-independent teachers. Thus, it can be conjectured that field-dependent teachers are more likely to have the student state the rule than are field-independent teachers--even if the teacher has a high conceptual level; that is, capable of generating many examples which reflect the rule.

Although conceptual level is primarily a measure of cognitive complexity and field-dependence-independence a measure of perceptual differentiation, both constructs have a social orientation. Whereas the conceptual level construct views the individual's social orientation in terms of degree of acceptance of other points of view as measured by the individual's stage of conceptual level, the field-dependence-independence construct views the individual in terms of interest in other people as measured by the individual's degree of field-dependence. While both of these constructs have been used separately in exploring classroom dynamics, it was anticipated that viewing an important aspect of mathematics teaching; namely, rule-example order, through both lenses would provide greater understanding of the classroom environment determined by teaching style.

Method

Seventy elementary education majors, mostly seniors, who were students in the undergraduate course, Methods of Teaching Mathematics and Science in the Elementary School, were the subjects in this study.

The prospective teacher's conceptual level was assessed by the Paragraph Completion Test (Hunt et al., 1973). Subjects were asked to write at least three sentences for each of six topics, e.g., "What I think about rules . . .," which were scored according to Hunt's criteria for measuring need for structure. The prospective teacher's field-dependence was assessed by the Group Embedded Figures Test (Oltman et al., 1971). Subjects were asked to locate a figure that is embedded within a field for eighteen different figures. Additionally, the subjects were asked to write five sentences which would express how they would teach each of two mathematics rules--one from arithmetic and one from geometry--and to indicate at which point in their presentation they would want the rule to appear. The arithmetic rule was: "When you multiply two numbers you get the same product whether you multiply the smaller number by the larger number or the larger number by the smaller number." The geometry rule was: "The area of a square is s X s where s is the length of a side of the square."

The following hypotheses were tested:

1. High CL teachers tend to provide more mathematics examples prior to discussion of the rule than low CL teachers who tend to discuss the rule early in the lesson.

2. Relatively field-dependent prospective teachers would prefer to have the students present the mathematics rule while relatively field-independent teachers would prefer to present the mathematics rule themselves.

3. High CL teachers who were relatively field-dependent would have the students state the mathematics rule while high CL teachers who were relatively field-independent would present the rule themselves.

4. No significant relationship exists between teacher conceptual level and person chosen to present the rule, nor between teacher field-dependence and number of examples presented prior to rule statement.

Results

To test hypothesis 1, conceptual level scores were partitioned as suggested by Hunt (1971) into categories of Low, Medium, and High, determined by scores of 0-1.4, 1.5-1.9, and 2 and above. The number of examples preceding rule discussion in the subjects' presentations were partitioned into categories of: 0, 1-2, and 3 or more. Chi-square analyses performed for the arithmetic presentation, geometry presentation, and the combined arithmetic and geometry presentations suggest, at .001 levels of significance, that prospective teachers with a high CL tend to present more mathematics examples preceding discussion of a rule than low CL teachers (Table 1). It should be noted that only 9 people chose to present the rule first in the arithmetic presentation while 22 chose to present the rule first in the geometry presentation. In examining the presentations, this investigator found that the subjects could generate many more applications of the arithmetic rule than the geometry rule which may account for the shift to present the rule earlier in the geometry presentation. This was the case for all stages of conceptual level.

insert Table 1 about here

To test hypothesis 2, the field-dependence scores were partitioned into three categories: relatively field-dependent (1-9), intermediate (10-13), and relatively field-independent (14-18). From the subjects' written presentations the rule presenter was classified into the categories of student or teacher. Chi-square analyses performed for the arithmetic and combined presentations suggest, at .01 and .005 levels of significance respectively, that prospective teachers who are relatively field-dependent tend to have

the student present the mathematics rule while relatively field-independent prospective teachers tend to present the mathematics rule themselves. While the data from the geometry presentation was in the direction suggested by the hypothesis, the findings were not at a significant level (Table 2). As mentioned earlier, the difference may be attributable to the limited applications of the geometry rule which were available to these prospective teachers.

insert Table 2 about here

To test hypothesis 3, only the 35 prospective teachers who had a high conceptual level score were considered. This group was partitioned with respect to field-dependence-independence score, and rule presenter, as in hypothesis 2. The levels of significance, determined by Chi-square analyses, were .01, .06, and .001, for the arithmetic, geometry, and combined presentations, respectively. That is, while high CL teachers as a group can provide many examples in considering a rule, those high CL teachers who are field-dependent prefer to have the student state the rule while high CL teachers who are field-independent prefer to state the mathematics rule themselves (Table 3).

insert Table 3 about here

To test hypothesis 4, conceptual level scores were partitioned as in hypothesis 1, and tested for independence with rule presenter, while field-dependence scores were partitioned as in hypothesis 2, and tested for independence with number of examples preceding rule discussion. The results of the Chi-analyses suggest that the variables are independent.

insert Table 4 about here

Implications

The results suggest that the differential cognitive/personality variables of conceptual level and field-dependence-independence are related to differential presentations of rule-example order in the teaching of mathematics. If these results are confirmed in future studies with both elementary and secondary school teachers of mathematics, then these constructs should be considered in the determination of matching models of students and teachers in the mathematics classroom. It would be of value to determine, depending upon desired outcomes, if high CL students who are field-independent should be put in mathematics classes where the teacher is also high CL and field-independent. Or would it be to the student's greater advantage to be placed with a high CL teacher who is field-dependent and thus more likely to encourage student determination of the mathematics rule? In the area of problem solving, there would seem to also be a need to consider these cognitive/personality constructs. For example, would the Dahmus method which "encourages the individual to translate information as it appears in the problem" be more effective with low CL students and/or teachers who are field-independent than the Polya method which "encourages the individual to look at the problem as a whole prior to beginning work on it (Bassler et al., 1975)"? Would low CL students and/or teachers who are field-dependent find the Polya method more effective than the Dahmus method? The question of providing preferential or compensatory treatment to students with respect to their conceptual level and field-dependence needs to be considered. Based on this study and others mentioned, methodology that recognizes the existence of person-environment interactions would seem to be more appropriate than methodology that considers only main effects.

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TABLE 1

CHI-SQUARE ANALYSES OF CONCEPTUAL LEVEL AND RULE-EXAMPLE ORDER

		Conceptual Level											
		Low	Medium	High		Low	Medium	High		Low	Medium	High	
number of examples preceding rule	0	3	5	1	9	8	10	4	22	11	15	5	31
	1-2	8	16	14	38	3	10	13	26	11	26	27	64
	3+	0	3	20	23	0	4	18	22	0	7	38	45
		11	24	35	70	11	24	35	70	22	48	70	140

Arithmetic Rule: $\chi^2 = 21.29$, df = 4, $p < .001$

Geometry Rule: $\chi^2 = 21.20$, df = 4, $p < .001$

Combined Rules: $\chi^2 = 41.61$, df = 4, $p < .001$

TABLE 2

CHI-SQUARE ANALYSES OF FIELD-DEPENDENCE-INDEPENDENCE AND RULE PRESENTER

		Field-dependence-independence											
		1-9	10-13	14-18		1-9	10-13	14-18		1-9	10-13	14-18	
rule presenter	teacher	7	12	17	36	13	16	18	47	20	28	35	83
	student	18	10	6	34	12	6	5	23	30	16	11	57
		25	22	23	70	25	22	23	70	50	44	46	140

Arithmetic Rule: $\chi^2 = 10.24$, df = 2, $p < .01$

Geometry Rule: $\chi^2 = 4.21$, df = 2, $p < .05$

Combined Rules: $\chi^2 = 13.42$, df = 2, $p < .005$

TABLE 3

CHI-SQUARE ANALYSES OF FIELD-DEPENDENCE-INDEPENDENCE AND RULE PRESENTER OF HIGH CONCEPTUAL LEVEL GROUP (N = 35)

Field-dependence-independence

		1-9	10-13	14-18		1-9	10-13	14-18		1-9	10-13	14-18	
rule presenter	teacher	1	6	10	17	5	7	11	23	6	13	21	40
	student	11	4	3	18	7	3	2	12	18	7	5	30
		12	10	13	35	12	10	13	35	24	20	26	70

Arithmetic Rule: $\chi^2 = 12.50$, df = 2, $p < .01$

Geometry Rule: $\chi^2 = 5.85$, df = 2, $p < .06$

Combined Rules: $\chi^2 = 16.54$, df = 2, $p < .001$

TABLE 4

CHI-SQUARE ANALYSES OF CONCEPTUAL LEVEL AND RULE PRESENTER

Conceptual Level

		Low	Medium	High		Low	Medium	High		Low	Medium	High	
rule presenter	teacher	7	12	17	36	9	16	22	47	16	28	39	83
	student	4	12	18	34	2	8	13	23	6	20	31	57
		11	24	35	70	11	24	35	70	22	48	70	140

Arithmetic Rule: $\chi^2 = 0.79$, df = 2

Geometry Rule: $\chi^2 = 1.36$, df = 2

Combined Rules: $\chi^2 = 1.89$, df = 2

CHI-SQUARE ANALYSES OF FIELD-DEPENDENCE-INDEPENDENCE AND RULE-EXAMPLE ORDER

Field-dependence-independence

		1-9	10-13	14-18		1-9	10-13	14-18		1-9	10-13	14-18	
number of examples preceding rule	0	5	2	2	9	7	9	6	22	12	11	8	31
	1-2	14	12	12	38	12	4	10	26	26	16	22	64
	3+	6	8	9	23	6	9	7	22	12	17	16	45
		25	22	23	70	25	22	23	70	50	44	46	140

Arithmetic Rule: $\chi^2 = 2.52$, df = 4

Geometry Rule: $\chi^2 = 5.17$, df = 4

Combined Rules: $\chi^2 = 3.74$, df = 4